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COVID-19 - Myocarditis and Return-to-play: Reflections and Recommendations from a Canadian Working Group

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Brief summary

COVID-19 infection has been associated with myocarditis and late gadolinium enhancement on cardiac MRI. Myocarditis has been implicated in sudden cardiac death of athletes. Return-to-play recommendations after COVID-19 infection for athletes and active persons are presented herein. In athletes with previous COVID-19 infection, return-to-play is recommended 7 days following viral resolution. Routine cardiac investigations (troponin, 12-lead ECG, and imaging) of these athletes are recommended only with the occurrence of cardiovascular symptoms.

Abstract

The SARS-Coronavirus-2 (COVID-19) related pandemic has resulted in profound health, financial and societal impacts. Organized sporting events, from the recreational to Olympic levels, have been cancelled to both mitigate the spread of COVID-19 and protect athletes and highly active individuals from potential acute and long-term infection associated harms. COVID-19 infection has been associated with increased cardiac morbidity and mortality. Myocarditis and late gadolinium enhancement (LGE) as a result of COVID-19 infection has been confirmed. Correspondingly, myocarditis has been implicated in sudden cardiac death (SCD) of athletes. A pragmatic approach is required to guide those who care for athletes and highly active persons with COVID-19 infection. Members of the Community and Athletic Cardiovascular Health Network (CATCHNet) and writing group for the *Canadian Cardiovascular Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes* recommend that highly active persons with suspected or confirmed COVID-19 infection refrain from exercise for 7 days after resolution of viral symptoms before gradual return to exercise. We do not recommend routine troponin testing, resting 12-lead electrocardiogram (ECG), echocardiography, or cardiac magnetic resonance imaging before return-to-play. However, medical assessment including history and physical examination with consideration of resting ECG and troponin can be considered in the athlete manifesting new active cardiac symptoms or a marked reduction in fitness. If concerning abnormalities on the initial medical assessment are encountered then referral to a cardiologist who cares for athletes is recommended.

Preamble

The COVID pandemic has resulted in major changes to all activities, including sport. These are the consequence of recommendations from health and government authorities and individual restraint due to health concerns. With care, some Canadian jurisdictions are now cautiously easing restrictions to permit the resumption of sport, and organizations and individuals are seeking direction as to how best address the health of athletes or highly active individuals. Specifically, guidance is required on how to evaluate those who have been infected or possibly infected with COVID-19, to ensure both safe sport reintegration and their individual well-being.

Questions regarding return to play include:

1) What, if any screening above and beyond current public health recommendations, should be performed to assess exposure or possible infection with COVID-19?

2) What testing recommendations should be pursued in athletes/highly active individuals with previously confirmed COVID-19 infection wishing to return to play?

3) How can a shared decision-making approach be implemented in the context of a return-to-play decision?

Members of the Community and Athletic Cardiovascular Health Network (CATCHNet) and writing group for the *Canadian Cardiovascular Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes* have summarized their approach to these important considerations during this time of transition. The focus is on return-to-play of athletes (defined as highly active persons who exercise and/or compete regularly at either a recreational or competitive level) with suspected or confirmed COVID-19 infection. This document is intended to supplement the *Canadian Cardiovascular*

Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes in order to provide further direction for active individuals who may not be under the umbrella of a CV screening program.

Background

The SARS-Coronavirus-2 (COVID-19) pandemic has had profound worldwide health, economic, and societal impacts, including substantial impact upon the sporting world. Gymnasiums, recreation centres, arenas were shuttered, and collegiate sports and the Olympics were postponed to both mitigate the spread of COVID-19, and protect exercisers and athletes. Despite the cessation of organized sports and restrictions placed upon the use of venues to perform exercise, athletes (from recreational to highly-competitive individuals), may contract COVID-19. In addition to the deleterious cardiac and respiratory effects imposed by the virus, the cessation of sports and implementation of health authority mandated quarantine to prevent the spread of the virus may pose additional negative consequences on an individual's well-being by affecting one's psychosocial health (increased anxiety, depression, weight gain, social deprivation, fear of seeking medical help, and school dropout).

Myocarditis is a concerning potential consequence of COVID-19 infection.[1] Myocarditis has been demonstrated to cause heart failure and sudden cardiac arrest/death.[2] Those who care for athletes or highly active individuals are faced with making 'return-to-play' recommendations for those who have suffered a COVID-19 infection. A pragmatic contextual approach that considers available health resources is required. In Canada, and many other jurisdictions with resource-limited public health systems that are stressed, particular considerations apply that form the

background for the present document. The desire to investigate and to *potentially* increase safety in this area of clinical uncertainty must be balanced by thoughtful resource utilization, and the risks and consequences of over investigation given the potential risks of unduly alarming athletes and restricting sport participation.

COVID-19 Cardiovascular Effects

COVID-19 infection can result in cardiovascular (CV) morbidity and mortality in hospitalized adult patients.[3, 4] Myocardial injury (elevation in cardiac troponin) is common in severe COVID-19 infection (38% of hospitalized patients) and if present, is associated with a marked increased mortality compared to those without myocardial injury (51.2 vs. 4.5%).[3] The degree and magnitude of myocardial injury in non-hospitalized persons with COVID-19 infection (including asymptomatic COVID-19 persons) is unknown as evaluation for markers of myocardial injury is not routinely carried out. The etiology of this myocardial injury is presumably multi-factorial and it is unclear what proportion of this represents direct viral or inflammatory myocardial damage (myocarditis) versus myocardial injury from hemodynamic or hypoxic stress following serious COVID-19 respiratory illness. Therefore, the proportion with, the etiology of, and prognostic value of elevated troponin levels in non-hospitalized COVID-19 patients remains unclear.

Myocarditis

Myocarditis is an inflammatory disease of the heart characterized by inflammatory infiltrates and myocardial injury of heterogenous etiology not from an ischemic cause.[5] The acute phase (1 to 3 days) of viral myocarditis is characterized by pathognomonic myocyte necrosis induced by virus replication after infection occurs. Exposure of intracellular antigens

may lead to the humoral activation and cellular immunologic processes aimed to eliminate the virus from the myocardium. Humoral activation to eliminate the virus from the myocardium follows, and may persist for several weeks to months. Immunologic activation, independent of viral genome detection, results in chronic post-infectious autoimmune myocarditis.[6] Epidemiological studies have shown that the incidence of viral myocarditis in the pre-COVID-19 era is estimated at 1.0–2.2 per 1,000,000 /year in adults.[7]

Myocarditis can result in scarring of the heart, ventricular dysfunction (transient or permanent), ventricular arrhythmias, cardiogenic shock, and sudden cardiac death (SCD).[5] Occult myocarditis has been implicated as a cause of SCD amongst young healthy individuals. Myocarditis was identified to be the third leading cause of SCD at 6% behind coronary artery abnormalities (17%) and hypertrophic cardiomyopathy (36%) in young competitive American athletes.[8] It is important to note, however, that the overall incidence of SCD in this population between 1980-2006 was estimated to be 0.61/100.000 athlete-years. In a contemporary autopsy series of the general population from Australia and New Zealand of the general population (ages 1-35 years), myocarditis accounted for 7% of all SCD. In a sudden cardiac arrest (SCA) series of competitive athletes from Ontario, Canada, 1 out the 16 arrests was possibly due to myocarditis; echocardiogram and ECG were normal, however, the MRI demonstrated scar. The overall incidence of SCA in this population was 0.76 cases per 100,000 athlete-years.[9] Amongst collegiate athletes in the National Collegiate Athletic Association (NCAA), 10% of SCD was attributed to myocarditis (overall incidence of SCD in this population was 1/53,703 athlete-years).[10] To put this into perspective, SCD attributed to myocarditis is 1 in 537,634/athlete-years in the NCAA, 1 in 1,098,901/year in the general population of young persons in Australia and

New Zealand, and 1 in 2,732,240/year in the study of American young athletes between 1980-2006.[8, 10, 11] Exercise in individuals with overt myocarditis *may* result in accelerated viral replication, increased inflammation and cellular necrosis, and a proarrhythmic myocardial substrate.[12, 13] COVID-19 has been implicated in the development of myocarditis, with accumulating pathological and imaging confirmation.[14-16]

Cardiac magnetic resonance (CMR) imaging data in recovered hospitalized and non-hospitalized COVID-19 patients, and non-hospitalized asymptomatic or minimally symptomatic collegiate athletes, has led to concern about the prevalence of late gadolinium enhancement (LGE) given its potential to represent subclinical or minimally symptomatic myocarditis.[4, 5, 17] Results from a much critiqued German study demonstrated some degree of CMR imaging abnormalities in 78% of recovered hospitalized and non-hospitalized COVID-19 general population patients (median age 49 years) who underwent non-clinically indicated CMRs as CMR was for research purposes and not for the intent of diagnosing suspected myocarditis. Sixty percent of patients had evidence of ongoing inflammation (edema) and 32% had evidence of LGE at a median of 71 days post-infection. There was an increased prevalence of LGE in the COVID-19 patients compared to healthy and risk factor matched control groups. However, ventricular size and biventricular function were within normal limits.[4] The impact of the CMR abnormalities on ventricular arrhythmias, ECG, and echocardiographic findings was not reported in this study.

In a population of COVID-19-positive American collegiate athletes (mean age 20.2 years) who underwent a CMR at a median time of 52 days post-infection; LGE was found in 9% with one athlete (5%) meeting the diagnosis of myocarditis.[6] None of the age-matched healthy controls and COVID-19 negative athletes had evidence of LGE or myocarditis.[18] Most relevant

to the return-to-play discussion from the findings of this small study is that among the COVID-19 positive athletes who had an ECG (20/22), troponin (18/22), or (21/22) echocardiogram testing, all had normal results. The two COVID-19 positive athletes who demonstrated inferoseptal LGE on CMR, had normal ECGs, negative troponin I, and normal echocardiograms with normal strain imaging. The only athlete diagnosed with myocarditis endorsed symptoms consistent with acute pericarditis and exertional chest tightness.[18]

In a separate study, 26 competitive collegiate athletes from Ohio with confirmed COVID-19 (46% mildly symptomatic; 54% asymptomatic) underwent ECG, troponin testing, and echocardiography on the same day as CMR.[17] No diagnostic ST/T wave changes on ECG were reported. Echocardiogram derived ventricular volumes and function were within normal limits. Troponin I was not elevated in any athlete. Nearly half of athletes (46%) had evidence of LGE. Four athletes (15%) had CMR findings consistent with myocarditis based on the updated Lake Louise Criteria.[6] Two athletes with CMR evidence of myocarditis had co-existing pericardial effusions. Of the four athletes with myocardial inflammation, two were asymptomatic, and two had mild symptoms (shortness of breath).[17] There was no COVID-19 negative control group in this study.

When considering return-to-play decisions for athletes with prior COVID-19 infection, the interpretation of the results of the studies published thus far[17, 18] warrants careful consideration. These exploratory observations include a total of 48 elite collegiate level athletes, where five athletes (10%) met criteria for myocarditis, and 29% demonstrated LGE. Whether the degree of myocardial injury can be extrapolated to other active populations is unknown.

Late gadolinium enhancement from non-COVID-19 symptomatic myocarditis has been associated with ventricular arrhythmias and SCD in athletes.[19] Furthermore, persisting LGE after

biopsy proven myocarditis is independently associated with an increased risk of SCD and overall mortality.[20] However, the long-term prognosis of incidentally detected CMR abnormalities, particularly in those not meeting diagnostic criteria for myocarditis, and in a predominantly asymptomatic post-COVID-19 population remain unknown. In a study of patients fulfilling diagnostic criteria of myocarditis (non-COVID-19 in origin), the majority of persons (50%) had regression in the amount of LGE at 3 months, and some (17%) experienced complete resolution of LGE by this time.[6, 21] With respect to COVID-19 myocarditis and presumed COVID-19 infection mediated LGE (some athletes may have had pre-existing LGE from non-COVID etiologies) , we do not yet know the magnitude of change in LGE with time as follow-up imaging studies have yet to be reported. Another unknown is the magnitude of potential increased SCD risk that exercise poses in a person with subclinical LGE. Even if the subclinical LGE is determined to be secondary to COVID-19 infection and represents a potential arrhythmic substrate, the extent of risk exercise poses remains uncertain.

How the results from CMR studies in athletes fit into contemporary expert return-to-play recommendations for myocarditis is unclear. In both studies, the athletes with LGE had normal troponin levels, normal ECGs and normal biventricular function on echocardiography, therefore, athletes with subclinical LGE would not be expected to be identified via conventional return-to-play testing modalities.[17, 18] In the absence of significant persistent symptoms or concerning ECG abnormalities on prolonged ECG monitoring and stress testing, the majority of these patients would have been cleared to return-to-play (ESC 2020; AHA/ACC 2015).[22-25] The presence of LGE, in and of itself, does not currently represent a rationale for ongoing exercise restriction beyond the acute inflammatory period, provided no other abnormalities are present at return-to-play testing (symptoms, abnormal exercise stress testing or abnormal prolonged ECG

monitoring.[22-25] As per the *European Society of Cardiology* guidelines, an athlete is permitted to resume sport in the presence of LGE provided there is an absence of LV dysfunction, ventricular arrhythmias and normalization of biomarkers.[20] To be clear, we are not advocating that CMR should never be performed in the context of COVID-19 suspected myocarditis, but we are recommending against the *routine* use of CMR in athletes with suspected or confirmed COVID-19 in the absence of other concerning clinical or diagnostic findings. CMR may be used to help confirm clinically suspicious myocarditis, and also be used to guide prognosis.[6, 20] With respect to resource utilization and stewardship, it should be noted that if LGE is discovered, follow-up clinical consultation and CMR is recommended.[26]

Differing approaches to return-to-play

Differing return-to-play guidelines for patients with either asymptomatic or mildly symptomatic COVID-19 infections exist, reflecting an area of substantial clinical uncertainty. A number of approaches have been proposed.[12, 27 28] All recommendations propose that the extent of evaluation be stratified by the severity of symptoms. **Asymptomatic athletes:** COVID-19 positive individuals who are asymptomatic are recommended to abstain from activity for a 2-week period before a graded return to exercise.[28] Recommendations by the *Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology*[27] and those appearing in *JAMA Cardiology*[12] suggest no cardiac evaluation whereas, in contrast, recommendations set forward in the *British Journal of Sports Medicine*[28] suggest consideration of a resting 12-lead ECG.[28] **Symptomatic athletes:** For symptomatic athletes with documented COVID-19 infection who do not require hospitalization, medical evaluation recommendations also vary. The *Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology*

suggest consideration of troponin and C-reactive protein testing. If troponin is abnormal then further testing with an electrocardiogram (ECG), echocardiogram, and CMR, ECG monitoring (Holter) are recommended.[27] Conversely, the *British Journal of Sports Medicine* recommendations suggest starting with a resting 12-lead ECG for symptomatic non-hospitalized individuals. If the ECG is abnormal or shows new repolarization changes compared to a prior ECG, then echocardiography (at a minimum) and cardiology consultation is recommended.[28] The *Canadian Olympic and Paralympic Sport Institute Network* have also developed recommendations for Canada's elite athletes.[29] A summary of the different recommendations is presented in *Table 1*. If testing results in a diagnosis of myocarditis (Table 2), then formal guidelines for sport participation should be followed.[24, 25] According to guidelines, for confirmed cases of myocarditis, it is recommended that athletes refrain from exercise programs for a period of 3 to 6 months to help ensure biological and clinical resolution of the disease.[24, 25] Current expert consensus recommended approaches to return-to-play post-COVID-19 infection agree that patients with confirmed myocarditis be treated in keeping with previously established guidelines. At present, there is no evidence that COVID-19 associated myocarditis is substantially clinically different from other forms of myocarditis which might to justify alternative approaches to care. Resumption of training is permitted after the period of restriction, provided LV function and serum biomarkers have normalized, and there is an absence of symptoms and clinically significant arrhythmia on ECG exercise stress testing and ECG ambulatory monitoring.[24, 25] In some cases, normalization of parameters may be faster than 3 to 6 months. This recommendation (3 to 6 months) is arbitrary and there are instances where earlier return-to-play may be considered.

Proposed return-to-play recommendations

The absolute numbers of highly active persons engaging in sporting activity with potential COVID-19 diagnosis is not insignificant (and may increase if virus spread increases), thus a pragmatic approach to return-to-play screening is required, reflecting the clinical uncertainty regarding risk, and the virtual impossibility of conducting mass CV testing of large segments of the population. We are only now developing an understanding of the prevalence and magnitude of cardiac involvement following COVID-19 infection. The long-term cardiac implications of COVID-19 infection are unknown. A cautious approach regarding the return to high intensity exercise (>70% of $\dot{V}O_{2max}$; >75% maximum heart rate) must meet the challenge of reducing SCD risk for athletes while minimizing the likelihood of inappropriate restriction. It is difficult to overlook the growing number of reports describing lingering CMR abnormalities in COVID-19 patients despite the mild severity of their illness. However, it is not feasible, nor practical, to perform a CMR on every COVID-19 positive exerciser, nor do we fully understand the implications of CMR findings in this context. In the small studies of collegiate COVID-19 positive athletes, for example, evaluation with ECG, troponin, and echocardiography were all reported as being within normal limits, and would have not identified the athletes with LGE on CMR.[17, 18] Based on currently available evidence, and in the context of the uncertain prognostic implications, our group has recommended *against* routine troponin, ECG, echocardiography and CMR in *asymptomatic* athletes with confirmed or suspected COVID-19 infection prior to exercise resumption.

Nevertheless, in concordance with the Canadian Cardiology Society position statement,[30] when considering return-to-play evaluation, a shared decision making approach with the patient/athlete is strongly recommended.[31] In this respect, a COVID-19 positive athlete who has

recovered from acute infection should be made aware of the limitations of the investigations for myocarditis, and the implications of a myocarditis diagnosis, which would lead to the recommendation of restriction from sport for 3 to 6 months and potentially longer, in association with ongoing follow-up. The health of the individual who is found to have significant cardiac abnormalities that *may* increase the risk of SCD is still of paramount focus for the physician. Within the Canadian system, the role of the physician is to diagnose, treat, and provide recommendations to the athlete while acknowledging limitations in prediction and prognostication, not to 'disqualify' the athlete unless the physician is under contract by a third party and not acting on behalf of the athlete, but that of their employer or institution. Athletes and health care providers should also be educated about symptoms, and recommended to exercise caution when gradually returning to high intensity exercise. Additionally, it is imperative that an athlete's mental well-being is not neglected. A COVID-19 diagnosis in of itself, let alone referral for cardiology evaluation with possible restriction from sport, may have potential deleterious effects on one's psychologic well-being. Given the global mental health crisis that has accompanied this pandemic, competitive and student athletes are amongst the many subpopulations that may present with heightened levels of anxiety, depression, and worry.[32-34] A properly executed shared decision making process, as well as the integration of psychological follow-up and intervention when necessary (particularly for COVID positive athletes who are restricted from participation), is recommended to reduce the overall mental health burden to athletes returning-to-play.

Cardiac evaluation of a highly active person with cardiac symptoms is clinically indicated, and far more likely to identify persons at a higher SCD risk as opposed to mass screening of a population merely presumed to be at risk. A stratified approach based on *new*

cardiac symptoms or diminished exercise performance is recommended. The stratification of COVID symptoms as mild, moderate and severe can be ambiguous, and there is no strong correlation between the severity of COVID-19 symptoms and associated degree of myocardial injury/cardiac involvement. For all athletes returning-to-play, it is recommended they be surveyed for current and prior or suspected COVID-19 infection in addition to new cardiac symptoms.(Figure 1) In the setting of organized systematic CV screening for competitive athletes as outlined in the *Canadian Cardiovascular Society Position Statement on the Cardiovascular Screening of the Young Athlete,* it is essential that the presence of high-quality emergency protocols (CPR training, automated external defibrillator accessibility, emergency action plan preparedness), remains the foundational element on which the safety of athletes rests, as potential long-term outcomes in terms of COVID-19 and SCA remain unknown.[35]

Recommendations:

Athletes and highly active persons suspected or confirmed COVID-19 and who have recovered (no active viral symptomatology) with no new active cardiac symptoms and no marked reduction in exercise capacity

Recommendation 1.

In the athlete recovered from a suspected or confirmed previous COVID-19 infection who exhibits no active cardiac symptoms nor a significant decrease in fitness/exercise performance:

1) A graded return can to exercise after at least 7 days after complete viral symptom resolution.

2) No additional screening testing required.

Practical Tips:

After complete viral symptom resolution, and if no active *cardiac* symptoms [palpitations, syncope, chest pain, dyspnea, unexplained increase in heart rate (Table 3)] are present, then a graded return to exercise >7 days after complete viral symptom resolution is recommended.[36] Continued monitoring for cardiac symptoms and/or recognition of an inability to regain fitness or a reduction in exercise capacity/performance is recommended. Routine troponin testing is *not* recommended in the *asymptomatic* athlete before return-to-play. If an athlete is within the context of an established CV screening program (i.e. collegiate, competitive sporting league, professional) and the physical examination and ECG are established components of that institutions' cardiac evaluation, the recommendation is to continue as previous. However, if the physical examination is not a component of the CV screening algorithm, we do not recommend implementing it due to the low sensitivity of a physical examination to diagnose myocarditis, in addition to reducing health care interactions and costs.

COVID-19 positive or suspected athletes and highly active persons manifesting with new cardiac symptoms or marked reduction in fitness

Recommendation 2.

In the athlete with suspected or confirmed COVID-19 infection who exhibits *new* or ongoing cardiac symptoms or a *new* decrease in performance:

1) Focused history and physical examination

2) Consideration of ECG and troponin

3) If concerning findings on history, physical examination and/or abnormal troponin and ECG, referral to cardiology and advanced cardiac imaging (echocardiography and/or CMR)

Practical Tips:

If *new* or ongoing *cardiac* symptoms (palpitations, syncope, chest pain, dyspnea, unexplained increase in heart rate) are present after COVID-19 infection, continued restriction from moderate-high intensity exercise is recommended. Medical assessment including a detailed cardiac history and physical examination should be performed. A resting 12-lead ECG and troponin *may* be considered as part of the initial evaluation. Cardiology referral is recommended if ECG abnormalities are present (Q waves, ST depression or elevation, T wave inversion, low voltage, new QRS widening or new bundle branch block, >2 premature ventricular contractions, >1st degree AV block), troponin is elevated , or there is clinical concern over cardiac symptoms and/or physical examination are present. It reasonable to proceed to CMR in athletes with a clinical diagnosis of myocarditis, overt abnormalities on ECG, echocardiographic abnormalities (wall motion abnormalities, ventricular dysfunction), and/or clinical deterioration. If myocarditis is diagnosed strenuous activity should be avoided, and exercise restriction may be considered for 3 to 6 months.[23, 24] If cardiac investigations are within normal limits but there are ongoing symptoms, longitudinal follow-up may be warranted.

Disclosures:

The above recommendations were created on behalf of the COVID-19 sub-committee of the Community & Athletic Cardiovascular Health Network, an umbrella group with expertise in sports cardiology, electrophysiology, exercise physiology, primary care and emergency medicine, and cardiac imaging, interested in the reduction of SCD in the athlete, supported by the Heart and Stroke Foundation, Canadian Cardiovascular Society, and Canadian Institute of Health Research. The subcommittee is undertaking further national investigative work to enhance general and COVID-19 related CV health of active persons. The recommendations presented herein, are not intended to replace established screening procedures but provide a framework for health care professionals evaluating return-to-play for exercisers/highly active persons with COVID-19.

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Table 1. A comparison of return-to-play recommendations following COVID-19 infection.

(table uploaded in separate document)

Table legend.

BNP - B-type natriuretic peptide; CMR – cardiac magnetic resonance imaging; CRP- C-reactive protein; ECG – 12-lead electrocardiogram; RTP – return-to-play

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considerations in competitive athletes. Br J Sports Med. 2020.

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Table 2. Diagnostic criteria for myocarditis.

Table 3. Table 3. COVID-19 Return-to-play questionnaire.

Figure 1. Suggested return-to-play for athletes and highly active persons in context of COVID-19 considerations.

^If an active person develops new cardiac symptoms regardless of COVID-19 status clinically indicated evaluation is recommended.

*Medical assessment should include a detailed cardiac history and physical examination. It may also include a resting 12-lead ECG and troponin.

#If red flags are identified then cardiology referral is recommended.

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	Proposed Canadian recommendations	British Journal of Sports Medicine[27]	JAMA Cardiology[11]	European Journal of Preventative Cardiology[26]	Canadian Olympic and Paralympic Sport Institute Network[28]
Time before return to sport after infection (positive test)	7 days after resolution of viral symptoms	Not specified	14 days from positive test result	Symptom free for 7 days	Symptom free for 10 days
RTP evaluation stratified by symptoms	No	Yes	Yes	Yes/No	Yes
Asymptomatic (COVID-19 positive test rest / No COVID-19 symptoms*)	Focused cardiac symptom history (see Appendix). If cardiac symptoms are present or a new reduction in fitness is present then medical assessment is recommended.	Focused medical history and physical examination Consider 12-lead ECG* If ECG is abnormal or shows new repolarization changes compared with a prior ECG, then additional evaluation with minimum echocardiogram and exercise test is warranted in conjunction with a sports	Rest/no exercise for 2 weeks from positive test result Close monitoring for symptom onset or late deterioration Slow resumption of activity after 2 weeks from positive test result under guidance of health care team	Refrain from exercise for 7 days, gradual return to exercise if remains symptom free, can consider repeat COVID-19 testing	Consultation with a physician for a history of physical examination. Based on clinical assessment and if prior cardiac history the following could be ordered: CRP and troponin, and ECG (consider ECG if athlete has pre-existing ECG). If ECG is abnormal proceed to echocardiogram.

		cardiologist			*if abnormal investigations refer to (sports) cardiologist
Symptomatic (COVID-19 positive test rest / COVID-19 symptoms present)	After resolution of viral symptoms, address presence of cardiac symptoms. The absence or presence and severity of COVID-19 viral symptoms* do affect cardiac evaluation framework. Focused cardiac symptom history. If cardiac symptoms are present or a new reduction in fitness is present then medical assessment is recommended.	*Mild symptoms; not-hospitalized* Focused medical history and physical examination to screen for persistent or new postinfectious findings following COVID-19 infection Perform 12-lead ECG If ECG is abnormal or shows new repolarization changes compared with a prior ECG, then additional individualized evaluation is warranted, including at minimum echocardiography and exercise	*Mild symptoms; not-hospitalized* • Rest/recovery with no exercise Consider further cardiac testing and/or hospitalization if development of cardiac symptoms Evaluation by a medical professional for consideration of return to activity: • hsTn • ECG •Echocardiogram • Consider additional symptom-guided testing If normal, slow return to activity and follow for clinical deterioration	Consider clinical assessment including troponin and CRP If troponin is positive then consider 12-lead ECG, echocardiogram, CMR and long-term ECG monitoring. If no evidence of cardiac involvement and symptom free consider gradual RTP after an additional 7 days	Consultation with a physician for a history of physical examination. Based on clinical assessment and if prior cardiac history the following could be ordered: CRP and troponin, and ECG (consider ECG if athlete has pre-existing ECG). If ECG is abnormal proceed to echocardiogram. *if abnormal investigations refer to (sports) cardiologist

		testing, in conjunction with a sports cardiologist.	If troponin elevated and/or abnormal cardiac study follow myocarditis guidelines[1, 2]		
Severe/Hospitalized	We do not recommend stratifying based on severity of COVID-19 symptoms. Upon discharge from hospital cardiac history should be implemented before return to exercise. If significant cardiac diagnoses (myocarditis) are diagnosed during hospitalization then follow myocarditis return-to-play guidelines. Focused cardiac symptom history. If cardiac	Comprehensive evaluation prior to return to sport, in conjunction with a sports cardiologist, to include blood biomarker assessment (hs-Tn and BNP), 12-lead ECG, echocardiography, exercise testing and ambulatory rhythm monitoring *If an athlete has documented myocardial injury (ECG changes, elevated troponin or BNP, arrhythmia or impaired cardiac	During hospitalization: • hsTn • Consider cardiac imaging per local protocols If normal, gradual RTP after 2 weeks and close monitoring for clinical deterioration If troponin elevated and/or abnormal cardiac study follow myocarditis guidelines[1, 2]		If systemic symptoms >10 days -> physician assessment with history and physical, troponin, CRP, ECG, echocardiogram, spirometry *if abnormal investigations refer to (sports) cardiologist

	symptoms are present or a new reduction in fitness is present then medical assessment is recommended.	function regardless of symptom severity require comprehensive evaluation before RTP by sports cardiologist with CMR and longitudinal follow-up if abnormal cardiac function			

BNP - B-type natriuretic peptide; CMR – cardiac magnetic resonance imaging; CRP- C-reactive protein; ECG – 12-lead electrocardiogram; RTP – return-to-play

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28. Canadian Olympic and Paralympic Sport Institute Network. Return to Health and Performance following COVID-19 Infection.

Table 3. COVID-19 Return-to-play questionnaire

1. Since confirmed or suspected COVID-19 infection have you experienced any of the following:
    a. Fainting or sudden loss of consciousness
    b. Chest pain, chest pressure, sharp pain in the heart or lungs when breathing or lying down
    c. Shortness of breath at rest or with exertion
    d. Increase in resting heart rate by >20 beats per minute
    e. Palpitations (heart racing, heart skipping or dropping beats)
    f. Marked reduction in fitness

Table 2. Diagnostic criteria for clinically suspected myocarditis

Newly abnormal 12 lead ECG and/or Holter and/or stress testing, any of the following:

- First to third degree atrioventricular block
- Bundle branch block
- ST/T wave change (ST elevation or non-ST elevation, T wave inversion)
- Sinus arrest
- Ventricular tachycardia or fibrillation and asystole
- Atrial fibrillation, supraventricular tachycardia
- Low QRS voltage
- Frequent premature ventricular contractions

Markers of myocardial injury

- troponin I/troponin T

Functional and structural abnormalities on cardiac imaging

Echocardiographic/angiographic/CMR

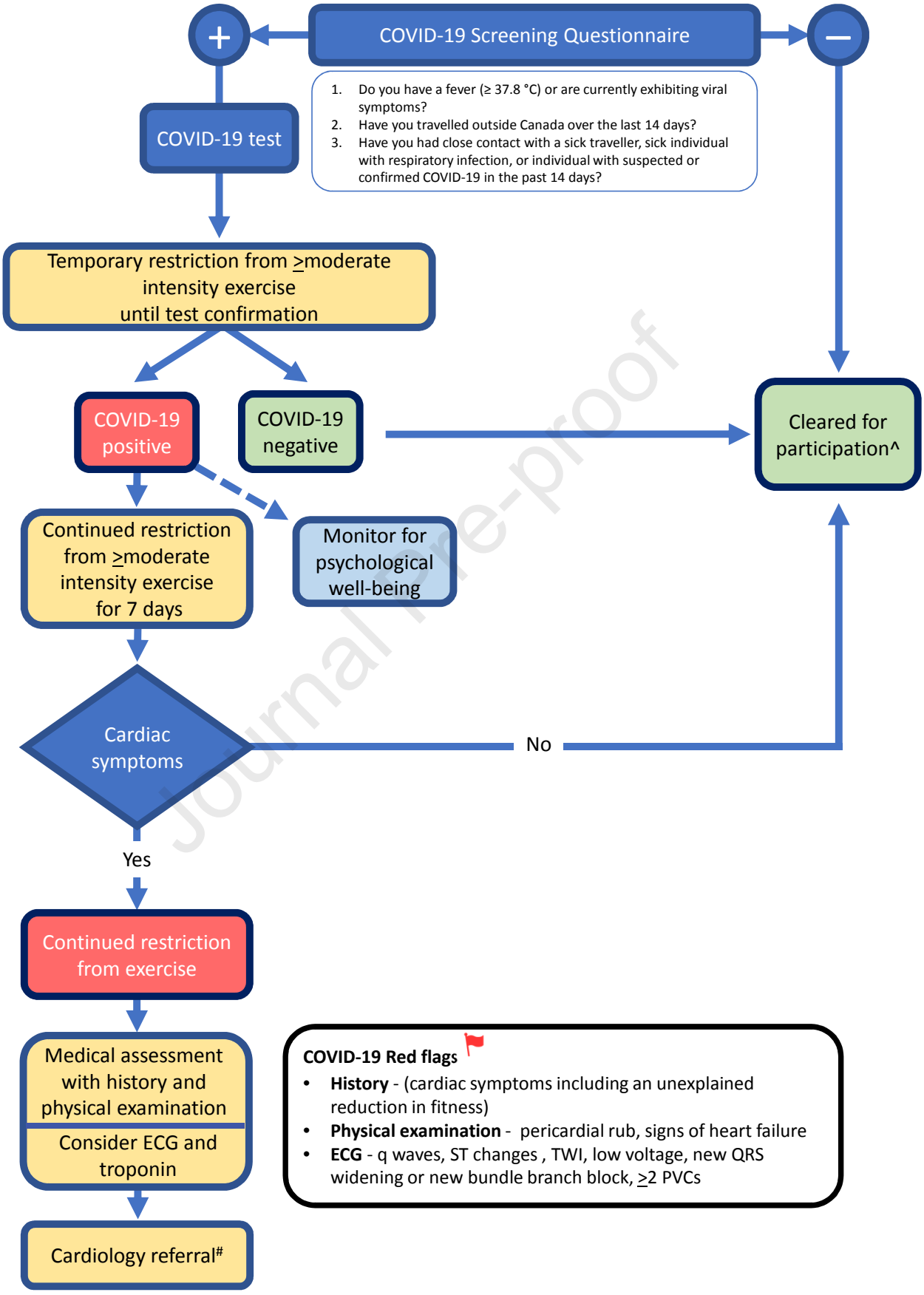
- Regional or global systolic or diastolic dysfunction, with or without LV dilatation Increased wall thickness
- Pericardial effusion
- Intracavitary thrombi

Tissue characterization by CMR (updated Lake Louise Criteria II*)

- Edema
- Hyperemia or capillary leak (early gadolinium enhancement)
- Irreversible injury (necrosis, scar; late gadolinium enhancement)

Clinically suspected myocarditis if >1 clinical presentation and >1 diagnostic criteria from different categories, in the absence of: (1) angiographically detectable coronary artery disease (coronary stenosis >50%); (2) known pre- existing cardiovascular disease or extracardiac causes that could explain the syndrome (e.g., valve disease, congenital heart disease, hyperthyroidism). Suspicion is higher with higher number of fulfilled criteria. If the patient is asymptomatic, >2 diagnostic criteria should be met.

Modified from "Caforio AL, Pankuweit S, Arbustini E, et al. Current state of knowledge on aetiology, diagnosis, management, and therapy of myocarditis: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. Eur Heart J. 2013;34:2636-2648, 2648a-2648d."


COVID-19 Screening Questionnaire
+
−
1. Do you have a fever (≥ 37.8 °C) or are currently exhibiting viral symptoms?
2. Have you travelled outside Canada over the last 14 days?
3. Have you had close contact with a sick traveller, sick individual with respiratory infection, or individual with suspected or confirmed COVID-19 in the past 14 days?
COVID-19 test
Temporary restriction from ≥moderate intensity exercise until test confirmation
COVID-19 positive
COVID-19 negative
Cleared for participation^
Continued restriction from ≥moderate intensity exercise for 7 days
Monitor for psychological well-being
Cardiac symptoms
No
Yes
Continued restriction from exercise
Medical assessment with history and physical examination
Consider ECG and troponin
Cardiology referral#
COVID-19 Red flags
History - (cardiac symptoms including an unexplained reduction in fitness)
Physical examination - pericardial rub, signs of heart failure
ECG - q waves, ST changes , TWI, low voltage, new QRS widening or new bundle branch block, ≥2 PVCs